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Force design analysis of the Army aeromedical evacuation company: a quantitative approach

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Abstract

This study illustrates a new approach to conducting capabilities-based analysis by assessing the requirements and capabilities of Army aeromedical evacuation units. We conducted a DOTMLPF (doctrine, organization, training, maintenance, leadership, personnel, facilities) assessment to determine gaps in the current force structure and solutions for future force design. Specifically, this study tackles the following research questions. RQ1: What are the gaps in medical evacuation mission execution for current operations and operations involving geographically dispersed units? RQ2: What capabilities might mitigate these gaps by examining the design characteristics of DOTLMPF? Our research design involved primary collection of data from senior aviation and medical aviation leaders using structured and unstructured survey questions. Using a mixed-method approach, we addressed RQ1 using quantitative methods and RQ2 through qualitative analysis. The results of our study determined the current organizational problems within the Army aeromedical evacuation unit, which can be leveraged for the future joint force design for vertical lift. Our evaluation of medical evacuation DOTMLPF considerations provides a baseline for assessing future Army materiel solutions.

Keywords

force design, capability assessment, mixed-methods, aeromedical evacuation

1. Introduction

1.1. Background

In this study, we illustrate new approaches to conducting capabilities-based analysis by assessing the requirements and capabilities of Army aeromedical evacuation units. We conducted the study in response to Army All Activities (ALARACT) Message #174, issued in 2010. The ALARACT message details both the problem statement and the requirements for the study:

> The experience in OIF (Operation Iraqi Freedom) and OEF (Operation Enduring Freedom) clearly indicates that requirements (both rotational and emergent) for medical evacuation (MEDEVAC) companies exceed General Support Aviation Battalion (GSAB) requirements. A significant number of MEDEVAC company requirements continue to deploy independent of their parent GSAB impacting other Combat Aviation Brigade (CAB) support assets. Army organizational designs must be full-spectrum capable and may not be optimized for conflicts such as OIF and OEF. Recent lessons learned identified a need to significantly augment the MEDEVAC company to ensure mission success. This augmentation enabled independent

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> operations in the areas of ground and air maintenance, petroleum oil and lubrication, personnel administration, food services, and operations.
>
> Commander, TRADOC (Training and Doctrine Command), in conjunction with Commander, MEDCOM (Medical Command), and in coordination with Commander, FORSCOM (Forces Command), will conduct a force design feasibility assessment on the optimal design for an air ambulance company. The assessment will determine the requirements for an independent capability with a separately reportable UIC (Unit Identification Code), identify force design options, present strategies to resource the offsets, and list the implications associated with these options throughout the force. A complete DOTMLPF (doctrine, organization, training, maintenance, leadership, personnel, facilities) and cost analysis is required as part of this assessment. The intent of the assessment is to present options to the senior Army leadership that address both readiness visibility and independent employment of air ambulance.[1]

In partial response to this directive, we conducted a DOTMLPF assessment to determine gaps in the current force structure and solutions for future force design. A DOTMLPF analysis is part of the Army's method for assessing force structure along appropriate force design domains.[2] The intent of this effort was to define any problems associated with current force structure and to solicit recommendations from aviation and medical aviation leaders regarding potential solutions in response ALARACT 174. Therefore, this study is critical for the future joint force design for vertical lift because it analyzes MEDEVAC DOTMLPF considerations necessary to identify where the Army should go in terms of future materiel solutions. This study, funded by the Medical Evacuation Proponency Directorate (MEPD), was conducted by Navigator Group, Incorporated, and coordinated with both Aviation Branch and Army Medical Department individuals.

This study is significant in that it incorporates primary data in a unique mixed-methods (quantitative and qualitative) approach to force design. Mixed methods add value in that both inductive and deductive methods may be combined to understand a phenomenon as well as measure it. Primary data provides direct and relevant commentary from those engaged in executing the missions of the units.

1.2. Literature review

Recent studies have illustrated the use of quantitative analysis supporting force structure decision making, especially in the Army medical arena. Previous research has illustrated the use of Monte Carlo simulation in analyzing force requirements for medical evacuation units.[3] This study coupled quantitative analysis of secondary data with a military case study. Another force structure article demonstrated the use of quantitative and qualitative analysis approaches in designing aeromedical evacuation companies (as well as other medical units).[4] Again, the study leveraged both inductive and deductive techniques but relied on secondary data. Other medical force structure and planning studies have leveraged optimization for both design[5] and personnel requirements,[6] stochastic optimization for determination of aeromedical evacuation asset requirements as well as emplacement,[7] and goal-programming formulations designed to assess both emplacement and demand considerations.[8]

Additional studies have demonstrated the use of qualitative approaches to force design analysis within the defense community. One such study addresses the integration of qualitative factors into Department of Defense medical treatment facility information systems for the improved development of manpower and staffing assessment models.[9] A decision analysis-based methodology with sequential qualitative assessments was developed to systematically evaluate potential materiel solutions for future combat systems.[10] A qualitative approach was used to analyze gaps between existing and future laboratory capabilities, which facilitated the evaluation of Navy medicine staffing, funding sources, organizational structure and research agendas.[11] Similar to our study, a mixture of qualitative and quantitative evaluation has been done to provide force development solutions, in terms of capabilities, to meet future utility helicopter requirements of the Army's Objective Force.[12] Furthermore, a new modeling framework and research methodology has been established to integrate qualitative social science with quantitative methods.[13] This study developed a procedure for translating textual reports of observations, interview transcripts, system documentation and figures into coded data for a US Air Force miniature uninhabited air vehicle product development system. Finally, force design analysis was conducted in response to a request by the Marine Corps Combat Development Command to provide a qualitative assessment of the Total Force Structure Division's troop-to-task analysis process.[14] This study proposed a systems model for capability-based assessment to match the suitable number and quality of personnel and equipment to a unit's mission essential task list.

1.3. Overview

The primary difference in this study compared to previous studies is that primary data garnered directly from senior enlisted, warrant and officer leaders provide the basis for analysis. The research questions for this study follow.

RQ1: What are the gaps (as measured by senior leader perceptions of DOTLMPF) in medical evacuation mission execution for current operations and operations involving geographically dispersed units? RQ2: What capabilities might mitigate these gaps by examining the design characteristics of DOTLMPF? These two research questions reflect a subset of the ALARACT problem statement. Specifically, the study quantitatively assesses design gaps and qualitatively assesses solutions. The scope of this study does not include the design of separate companies and associated cost analysis.

A gap is operationally defined by the perception of aviation and aeromedical evacuation leaders in the areas of DOTMLPF. These perceptions are measured on a Likert scale, calibrated through a pilot survey and tested for reliability. 'Mitigating capability' is assessed by deriving themes from open-ended responses of survey respondents. We touch on mitigating solutions only briefly in this study.

2. Method

2.1. Study design

Our research design involved primary collection of data from senior aviation and medical aviation leaders using structured and unstructured survey questions. The population of primary interest as determined collectively by the study group was the leadership of the Army aviation and medical aviation communities. Army aviation leaders might have perspectives incongruent with medical aviation leaders, and so areas of concurrence would reflect primary areas requiring organizational redesign. Since Army medical evacuation units fall under the Aviation Branch's GSAB, the study group also determined that it was both necessary and appropriate to query leaders of both groups and to determine differences between the groups as required.

Using the Army Aviation Association of America *Blue Book Directory*[15] listing of senior Army aviation leaders, as well as the medical evacuation leader directory maintained by the MEPD, we collected an email list of 653 senior leaders (battalion commanders, command sergeants major, company commanders and first sergeants). This list served as our sampling frame.

Our survey design directly queried the senior leaders about efficacy of current operations and then separately regarding dispersed operations using the DOTLMPF format. We focus on the results from the following questions. Respondents were asked to assess the following: 'Considering only the aeromedical evacuation company, assess its organic ability against {H1: the mission requirements of Afghanistan and Iraq or H2: the mission requirements of conducting MEDEVAC operations while geographically dispersed from its parent GSAB}. Do not consider contractors or contract maintenance.' The respondents were then asked to rate their concurrence with the following statement: 'The organizational capability meets the requirement.' The Likert-scale survey coding follows: {–3=Strongly Disagree, –2=Disagree, –1=Partially Disagree, 0=Unsure, 1=Partially Agree, 2=Agree, 3=Strongly Agree}. Since the questions regarding current operations and geographically dispersed operations were identically formulated and since current operations are largely geographically dispersed (albeit not necessarily separated from the GSAB), we anticipated that we could check the reliability of the survey by comparing the two sets of questions. If responses by individuals were similar on the two sections, then we would be assured that the instrument itself was reliable. We also included, per the request of the study sponsor, additional questions for medical evacuation leaders only. These questions were intended to document those areas that required specific knowledge of medical evacuation day-to-day operations. In order to conduct grouped analysis, respondents were asked: 'Please identify if you served in a medical evacuation company.' To validate the survey instrument, we piloted the survey on individuals in both the aviation and medical evacuation communities.

2.2. Hypothesis testing

We restate the research questions for clarity. RQ1: What are the gaps in medical evacuation mission execution for current operations and operations involving geographically dispersed units? RQ2: What capabilities might mitigate these gaps by examining the design characteristics of DOTLMPF?

To address these two research questions, we used quantitative analysis of the Likert-scale survey to identify statistically significant gaps, while we used analysis of qualitative data to identify themes that would provide potential solutions to those gaps. We analyzed the following alternative hypotheses for both current operations (defined as ongoing operations in Afghanistan and Iraq) and separately for geographically dispersed operations (defined as medical evacuation units operating separately from their parent unit). H1* defines hypotheses associated with current operations, whereas H2* defines those associated with geographically disperse operations:

- H1a/H2a: The mean perception of surveyed leaders regarding the number of medical personnel is significantly different from zero.
- H1b/H2b: The mean perception of surveyed leaders regarding the training of medical personnel is significantly different from zero.
- H1c/H2c: The mean perception of surveyed leaders regarding the amount of medical equipment is significantly different from zero.

Table 1. Descriptive statistics for select variables.

	Gender, Male =1	Age	Years in Military	Months Deployed	Months in GSAB
Mean	0.94	42.28	21.2	18.33	22.68
Std error	0.02	0.71	0.72	1.25	2.35
Median	1	44	23	14.5	16
Mode	1	47	26	12	0
Std dev.	0.24	7.13	7.18	12.48	23.47
Skewness	− 3.76	− 0.41	− 0.61	0.68	0.84
Range	1	33	31	57	73
Minimum	0	26	3	0	0
Maximum	1	59	34	57	73
Count	100	100	100	100	100

GSAB: General Support Aviation Battalion

- H1d/H2c: The mean perception of surveyed leaders regarding the appropriateness of medical equipment is significantly different from zero.
- H1e/H2e: The mean perception of surveyed leaders regarding the number of aviators is significantly different from zero.
- H1f/H2f: The mean perception of surveyed leaders regarding the training of aviators is significantly different from zero.
- H1g/H2g: The mean perception of surveyed leaders regarding the number of aircraft is significantly different from zero.
- H1h/H2h: The mean perception of surveyed leaders regarding the number of maintenance personnel is significantly different from zero.
- H1i/H2i: The mean perception of surveyed leaders regarding the training of maintenance personnel is significantly different from zero.
- H1j/H2j: The mean perception of surveyed leaders regarding the amount of maintenance equipment is significantly different from zero.
- H1k/H2k: The mean perception of surveyed leaders regarding the appropriateness of maintenance equipment is significantly different from zero.
- H1l/H2l: The mean perception of surveyed leaders regarding the number of enlisted is significantly different from zero.
- H1m/H2m: The mean perception of surveyed leaders regarding the number of warrant officers is significantly different from zero.
- H1n/H2n: The mean perception of surveyed leaders regarding the number of officers is significantly different from zero.
- H1o/H2o: The mean perception of surveyed leaders regarding the leadership in medical evacuation units is significantly different from zero.
- H1p/H2p: The mean perception of surveyed leaders regarding the appropriateness of aircraft is significantly different from zero.

Hypotheses pairs for H1* and H2* are related in content. Thus, we used Bonferonni corrections for these pairs. With a priori α=.10, the Bonferonni correction results in α =.10/2 = .05. An appropriate test for each hypothesis (based on non-normal data) is the binomial test, where negative response values are compared against positive response values with the assumption that each should be equally likely. Specifically, we evaluate the following probability statement:

$$P(X \geq x|N = n,\ p = .5) = \sum_{x}^{n} \binom{n}{x} p^x (1-p)^{n-x}$$

The binomial probability distribution is the appropriate model when the following exist:

a. two outcomes exist (dichotomous experimental results, e.g. {agree, other than agree});
b. counts are made for one outcome, e.g. {agree};
c. a fixed number of trials, N;
d. an assumed a priori and fixed probability (e.g. pi = .5, equally like to agree versus other than agree);
e. independence (or near independence) of experiments (e.g. sample size is with replacement or sufficiently large such that the hypergeometric and binomial probabilities nearly converge).

In our study, all five assumptions hold. Further, the sign test (a non-parametric test for dichotomous outcomes) is nothing more than a binomial where ties are discarded.

3. Results and Discussion

Of these 650 surveys, we received n=100 usable responses for a reasonable 15.3% response rate. The respondents

Table 2. Grade distribution of respondents.

Grade	Rank	Count	Percent
E-6	Staff Sergeant	2	2.1%
E-7	Sergeant First Class	9	9.3%
E-8	Master Sergeant	8	8.2%
E-9	Sergeant Major	7	7.2%
W-2	Warrant Officer Two	1	1.0%
W-3	Warrant Officer Three	0	0.0%
W-4	Warrant Officer Four	6	6.2%
MW-5	Master Warrant	1	1.0%
O-2	First Lieutenant	1	1.0%
O-3	Captain	14	14.4%
O-4	Major	16	16.5%
O-5	Lieutenant Colonel	20	20.6%
O-6	Colonel	12	12.4%

Table 3. Distribution of respondents by component.

Status	Count	Percent
Regular Army	45	45%
National Guard	50	50%
Army Reserves	2	2%
Contractor/other	3	3%

were 94% male. The median age was 44, and the median years of military service was 23. Respondents reported a median of 14.5 months deployed and 16 months assigned to the GSAB. Table 1 details these statistics.

The mode for respondent grade of rank was O-5 (lieutenant colonel), while the mode for respondent component was the National Guard (50%). Tables 2 and 3 provide the distributions:

To test the reliability of the survey, we analyzed respondents' answers to questions regarding current operations and compared them with answers to the 'geographically dispersed' section. In all pairwise comparisons of questions except for one (training of aviators), we found Cronbach's $\alpha > .7$, indicating the reliability of responses. For training of aviators, Cronbach's α was equal to .67.

The results of the survey indicated that for current operations, leaders expressed satisfaction with the following: training of aviators, training of maintainers, the number of officers, the leadership, the appropriateness of medical equipment, the amount of medical equipment, the training of medics, the appropriateness of aircraft, the number of warrant officers, and the appropriateness of maintenance equipment. The leaders expressed dissatisfaction with the number of enlisted soldiers and the number of maintainers. No other statistically significant findings emerged. Table 4 provides the results of the binomial tests for current operations.

The results of the survey for geographically dispersed operations were consistent with those of current operations. Leaders expressed satisfaction with the following: training of aviators, number of officers, leadership, appropriateness of medical equipment, amount of medical equipment, the number of warrants, the training of maintainers, and the appropriateness of the aircraft. The leaders expressed dissatisfaction with the number of maintainers, the amount of maintenance equipment and the number of enlisted. Table 5 provides the results of the binomial tests for geographically dispersed operations.

We also analyzed differences in opinions for those who had served in medical evacuation units and those who had not on the assumption that perhaps differences might exist

Table 4. Binomial tests for agreement versus disagreement, current operations, + is statistically significant positive opinion and – is statistically significant negative opinion.

Variable	Negative	Positive	Total	Unsure/no answer	*p*-value
+ Training of aviators	10	60	70	30	< .001
+ Training of maintainers	13	56	69	31	< .001
+ Number of officers	14	56	70	30	< .001
+ Leadership	15	54	69	31	< .001
+ Appropriateness of med equip.	16	53	69	31	< .001
+ Amount of medical equipment	17	51	68	32	< .001
+ Training of medics	20	49	69	31	< .001
+ Appropriateness of aircraft	21	48	69	31	0.001
− Number of enlisted	47	23	70	30	0.003
+ Number of warrants	23	47	70	30	0.003
− Number of maintainers	45	25	70	30	0.011
+ Appropriateness of main. equipment	27	42	69	31	0.046
Number of aviators	28	42	70	30	0.060
Number of medics	40	30	70	30	0.141
Amount of maintenance equipment	32	37	69	31	0.315
Number of aircraft	35	34	69	31	0.500

Table 5. Binomial tests for agreement versus disagreement, geographically dispersed operations, + is statistically significant positive opinion and – is statistically significant negative opinion.

Variable	Negative	Positive	Total	Unsure/no response	*p*-value
+ Training of aviators	15	47	62	38	< .001
+ Number of officers	15	47	62	38	< .001
+ Leadership	15	46	61	39	< .001
+ Appropriateness of med equip.	17	44	61	39	< .001
+ Amount of medical equipment	18	43	61	39	0.001
– Number of maintainers	43	18	61	39	0.001
– Amount of maintenance equipment	41	20	61	39	0.005
– Number of enlisted	40	22	62	38	0.015
+ Number of warrants	22	40	62	38	0.015
+ Training of maintainers	22	39	61	39	0.020
+ Appropriateness of aircraft	23	38	61	39	0.036
Training of medics	25	36	61	39	0.100
Appropriateness of main. equipment	26	35	61	39	0.153
Number of aviators	27	35	62	38	0.187
Number of medics	32	29	61	39	0.399
Number of aircraft	31	30	61	39	0.500

Table 6. Fisher's exact tests by those who served in medical evacuation (MEDEVAC) versus those who did not.

Current operations	Direction	*p*-value
Medic training	Non-MEDEVAC > MEDEVAC	0.040
Training of maintainers	Non-MEDEVAC > MEDEVAC	0.044
Amount of maintenance equipment	Non-MEDEVAC > MEDEVAC	0.007
Appropriateness of maintenance equipment	Non-MEDEVAC > MEDEVAC	< .001
Geographically dispersed operations	**Direction**	***p*-value**
Medic training	Non-MEDEVAC > MEDEVAC	0.025
Appropriateness of maintenance equipment	Non-MEDEVAC > MEDEVAC	0.031

using the hypergeometric probability distribution (Fischer's Exact test). Indeed, we found areas of concordance and discordance as expected. Specifically, we found statistically significant differences in perceptions of medic training, maintainer training, amount of maintenance equipment and appropriateness of medical equipment, as illustrated in Table 6.

For the qualitative analysis, we used text-mining techniques to analyze themes associated with free-text comments of the respondents. We looked for common ideas and insights, and then grouped the textual comments accordingly. Some of the themes that emerged from the qualitative analysis were as follows: insufficient medic density (24 comments); requirement for paramedics (19 comments); requirement for additional maintainers, technical inspectors and shop equipment (23 comments).

Respondents also provided excellent force structure recommendations to address deficient areas. A common theme from those who served in MEDEVAC units was the establishment of an aviation unit maintenance platoon, as the current structure has all maintenance in the GSAB maintenance company. This theme did not emerge from those who did not serve in medical evacuation companies.

4. Concluding Remarks

The results of this analysis indicate some clear and congruent issues associated with the medical evacuation force structure. Firstly, we note many areas of the organizational design appear to be adequate based on assessment of senior leaders. All elements of DOTMLPF except for M and P (maintenance and personnel) were rated as reasonably sufficient. Despite the proper design in these areas, the number of enlisted soldiers, the number of maintainers and the amount of maintenance equipment were identified as areas of concern for geographically dispersed operations. For current operations, the number of maintainers and the number of enlisted soldiers were notable shortcomings. In addition, we noted that an opinion disparity existed for those who served in MEDEVAC units versus those who had not served in the areas of medic and maintainer training, as well as in the amount and appropriateness of maintenance equipment. Those who had not

served in MEDEVAC units rated these areas much higher than those who had served.

From a holistic perspective, we see that the problem areas in the medical evacuation company design appear to be in maintenance and manpower. The maintenance structure supporting the medical evacuation company appears to be insufficient in terms of number of maintainers and amount of equipment. Detail of the exact shortages coupled with costing of any changes is part of the follow-on analysis. By determining the current organizational problems within the aeromedical evacuation unit, the results of this study can be leveraged for the future joint force design for vertical lift. Our mixed-methods approach to evaluating MEDEVAC DOTMLPF considerations provides a baseline for assessing future Army materiel solutions.

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